Performance Characteristics of High Brightness (HB) White LEDs for General Outdoor Illumination

BETA LED

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Beta Lighting

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Optimizing Integration for Fixture Design and Applications

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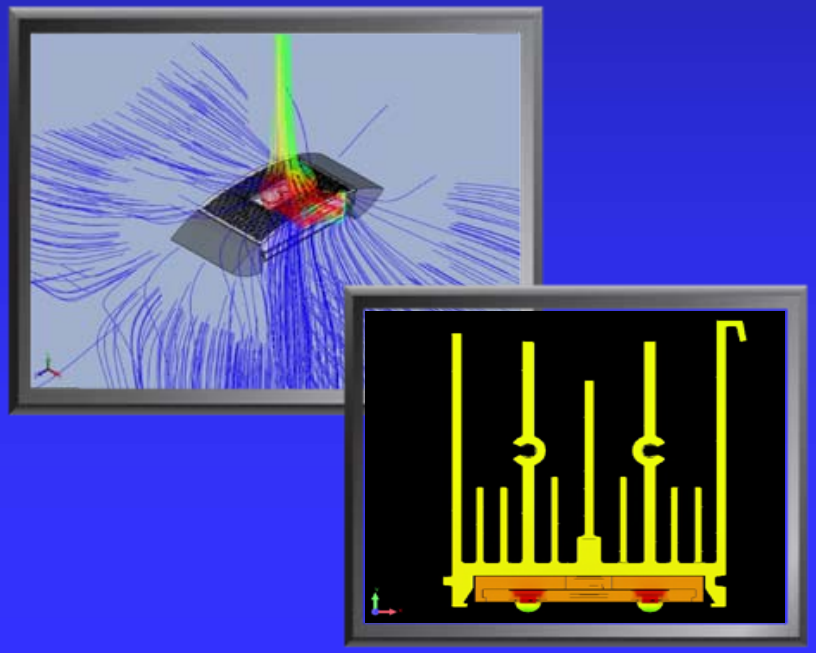
Thermal Management



Optical Control

Thermal Management

- Key System Optimization Attribute
  - Dramatic Effects On:
    - Initial System Efficacy
    - Lumen Depreciation / Lumen Maintenance

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Understanding Thermal Effects on Performance

- **Goal:**
  - Optimizing Efficacy
  - Optimizing Life / Minimizing Lumen Depreciation

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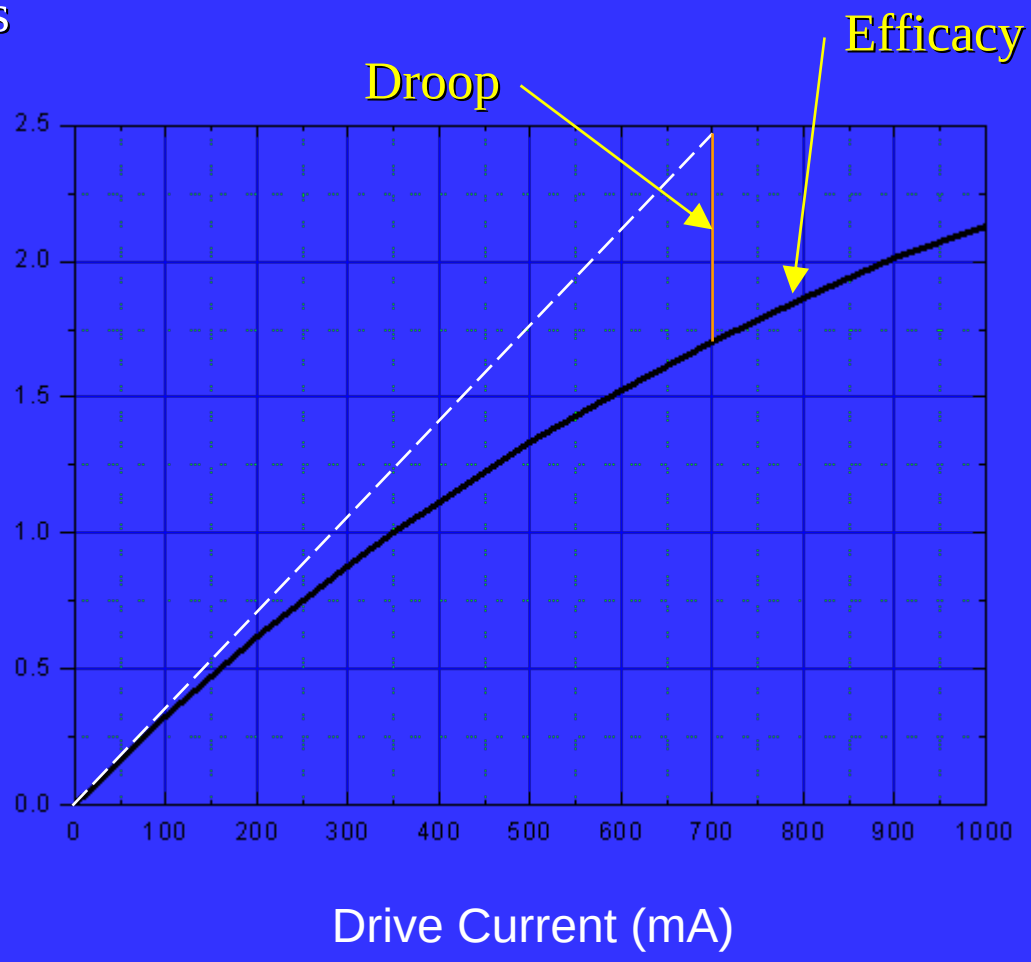
HB White LED Source Efficacy

- Example
  - 80+ Lumens/Watt
    - Measured at 25°C
      - ~25 Millisecond Time Duration
      - 350 mA Drive Current
    - ~6000 K Correlated Color Temperature (CCT)
      - Limited Indoor Applications
      - Appropriate for Many Outdoor Applications

HB White LED
Relative Initial Source Efficacy

- At Constant Time and Junction Temperature
  - Drive Current Varies



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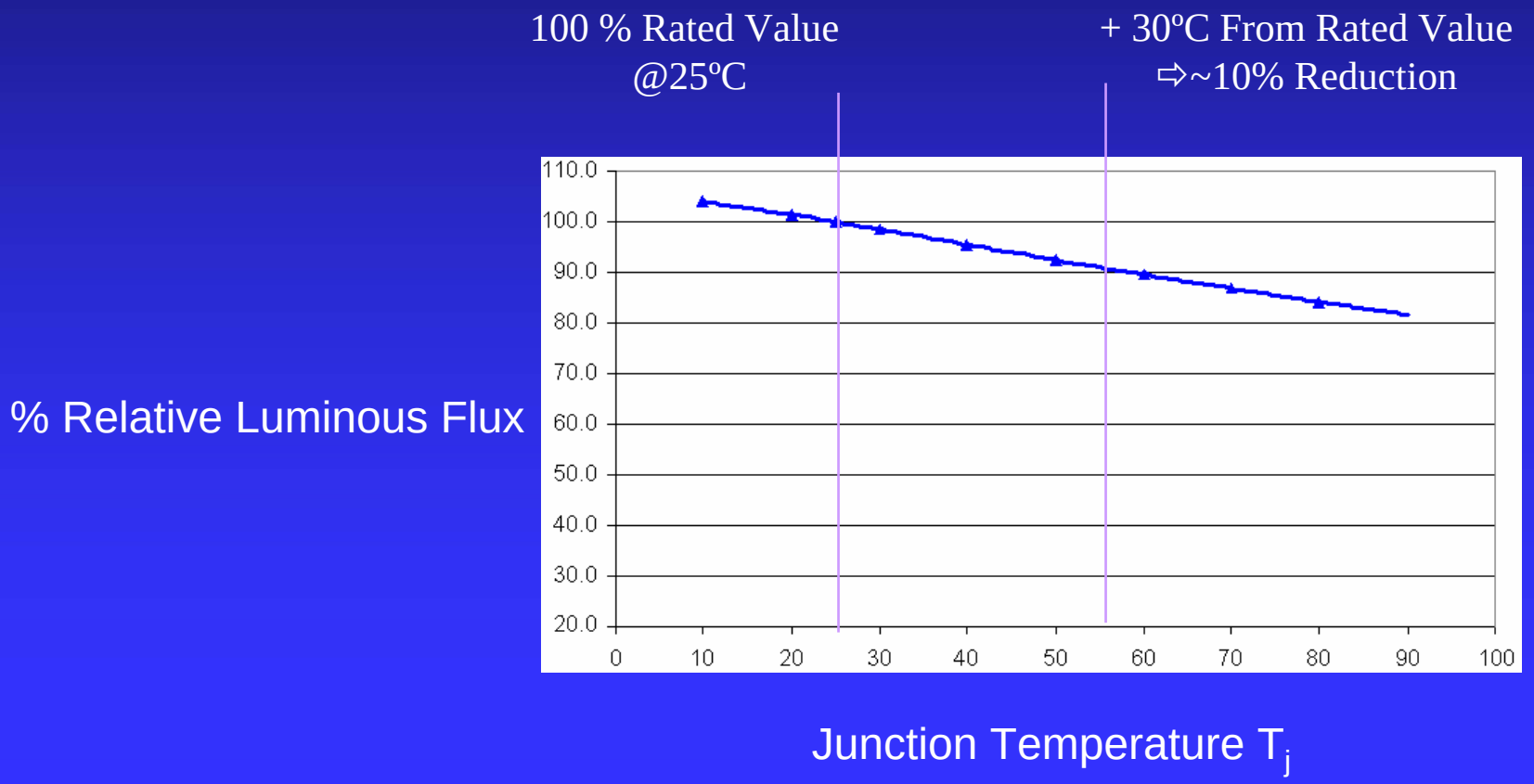
HB White LED
Relative Initial Source Efficacy

- At Constant Time and Drive Current
  - Junction Temperature (T_j) Varies



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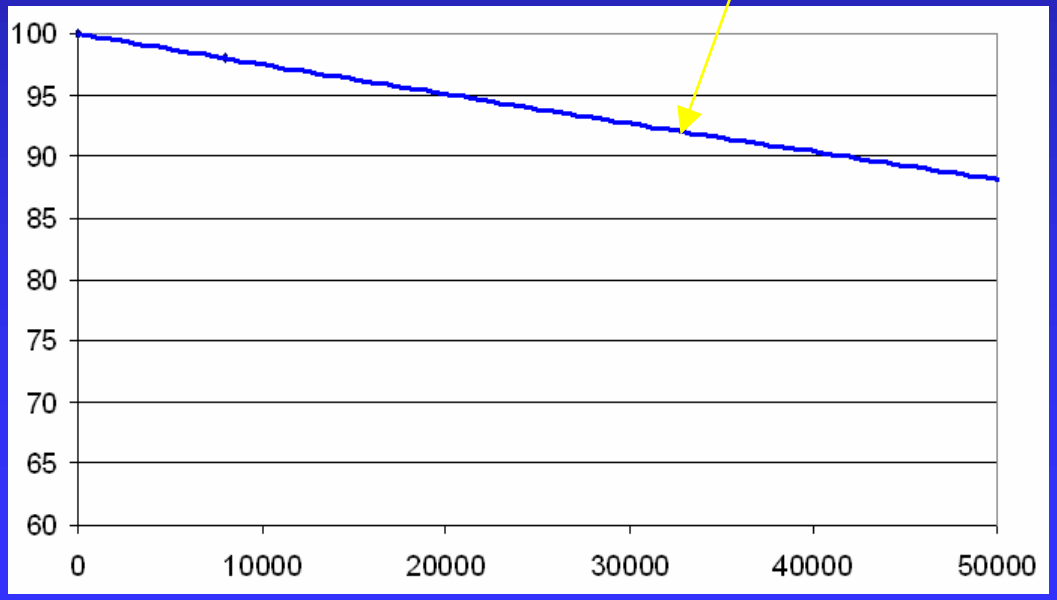
HB White LED
Source Efficacy Over Time

- At Constant Junction Temperature (T_j) and Drive Current
  - Example: Stabilized LED System
  - Time Varies
    - *Defines Lumen Maintenance*

Example: For T_j of ~55°C
⇨~12% Reduction @ 50,000 Hrs



% Relative Luminous Flux

Time (Hours)

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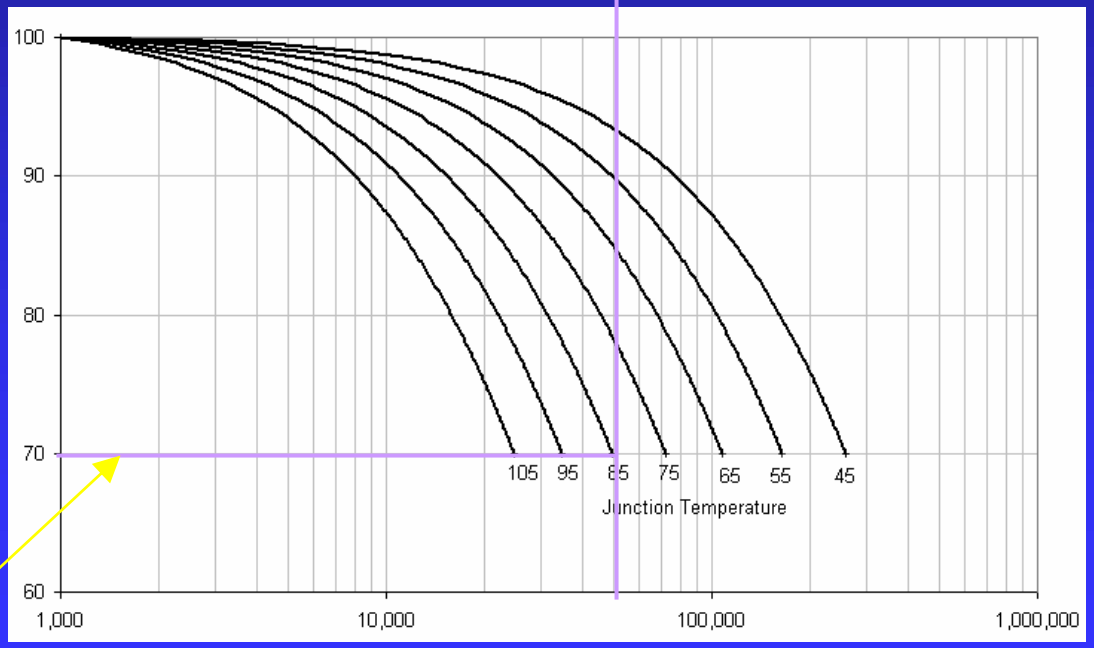
HB White LED
Source Efficacy Over Time

- At Constant Junction Temperature (Tj) and Drive Current
  - Example: Stabilized LED System
  - Multiple (Tj) Examples
  - Time Varies

For T_j of ~85°C
⇨~30% Reduction @ 50,000 Hrs



% Relative Luminous Flux

L_{70}

Time (Hours)

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Important Points

- Thermal Management Will Determine Lumen Depreciation
- Thermal Management Will Directly Impact Initial System Efficacy
  - Complete System Must Be Tested
    - Requires Absolute Photometry

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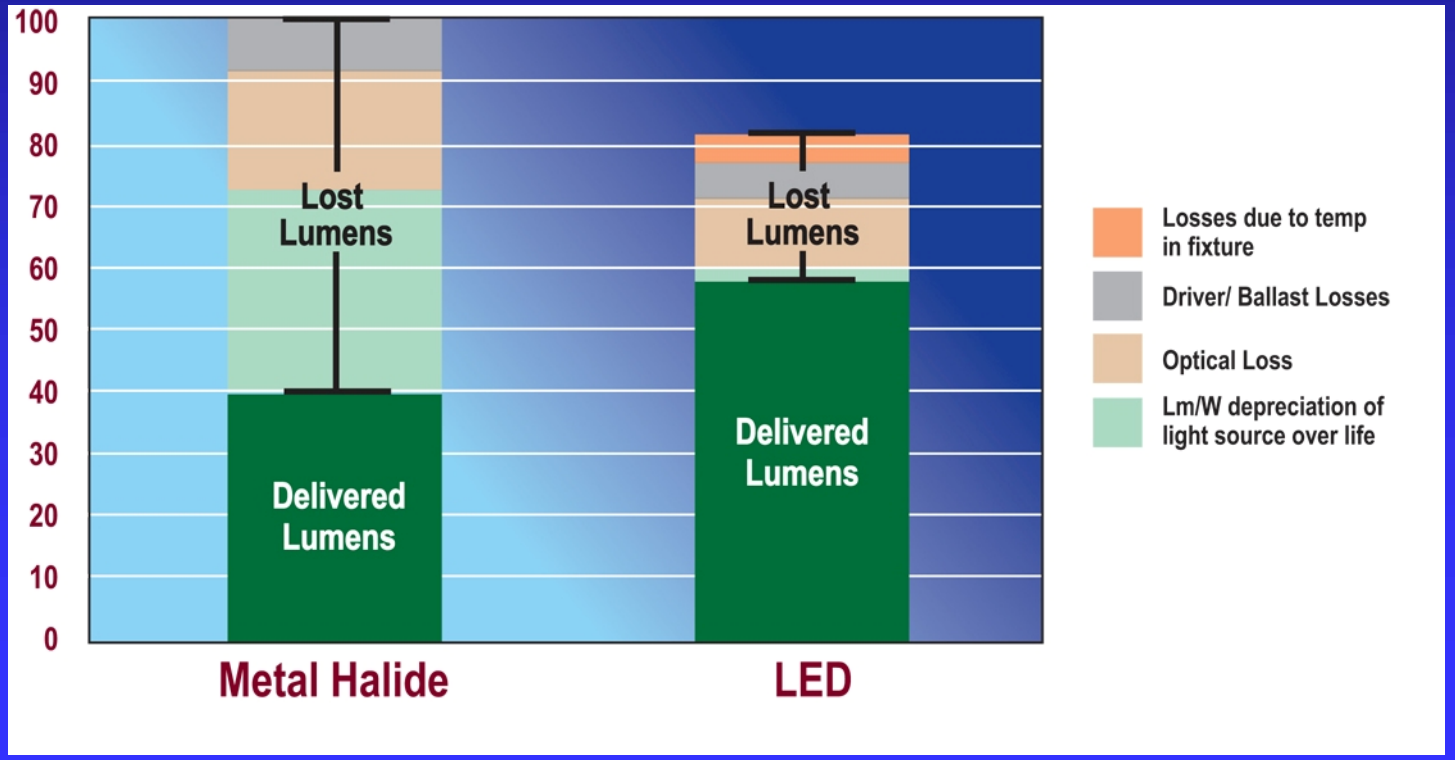
Basic System Comparison Example

- 100 Lumen/Watt Metal Halide
- 82 Lumen/Watt LED



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Optical Control Opportunities

- HID vs. LED

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Source Size and Directionality

- HID
  - Relatively Small Size
  - Omni-Directional Emission
    - Intensity at Angle Varies

Source Size and Directionality

- LED
  - Relatively Small Size
  - Emission Usually Contained in a Solid Angle Less Than 120º
    - Intensity at Angle Varies

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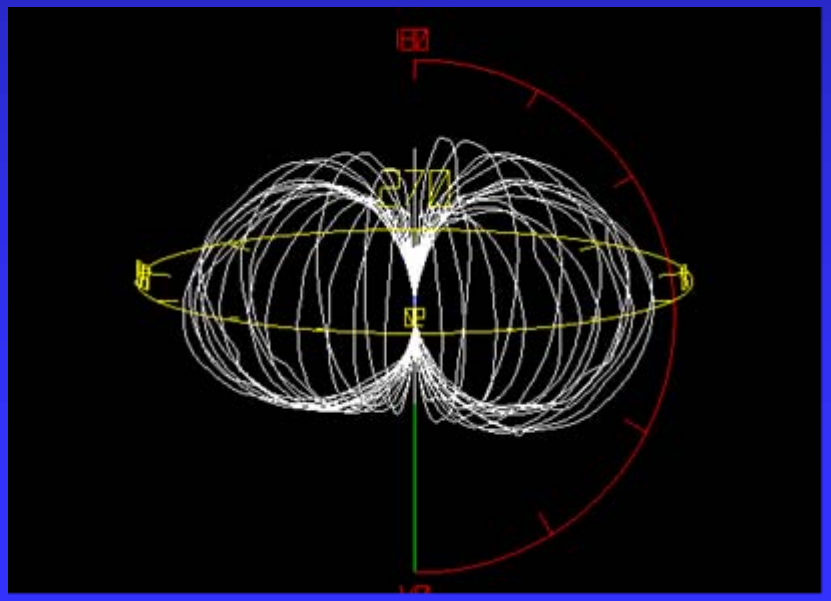
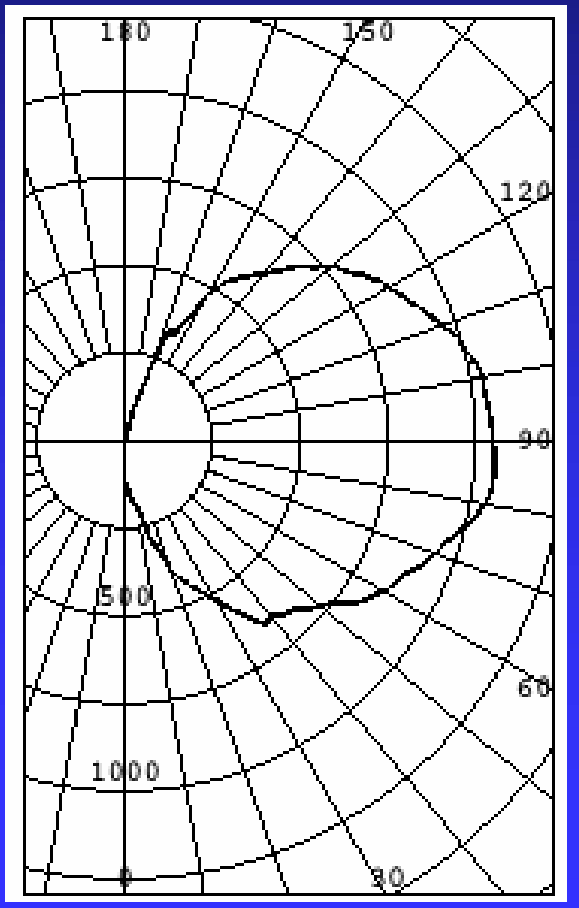
Bare Source Emission Characteristics

HID Bare Source Photometry

Commercially Available MH Lamp
Polar Candela Plot





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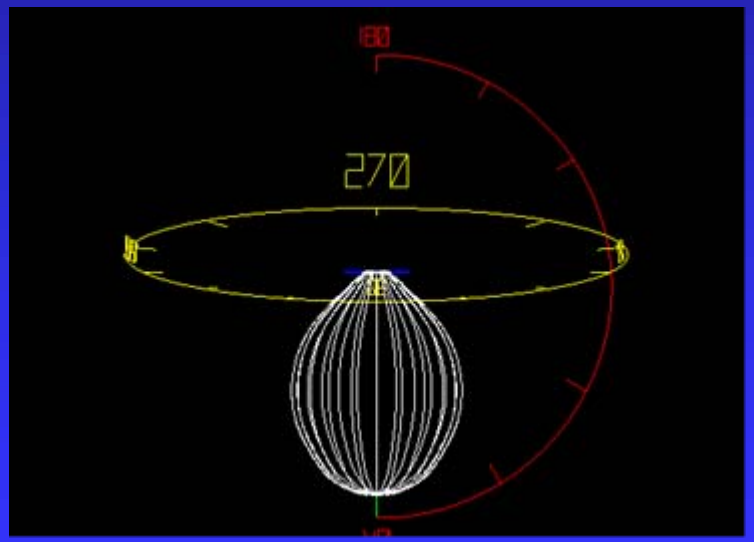
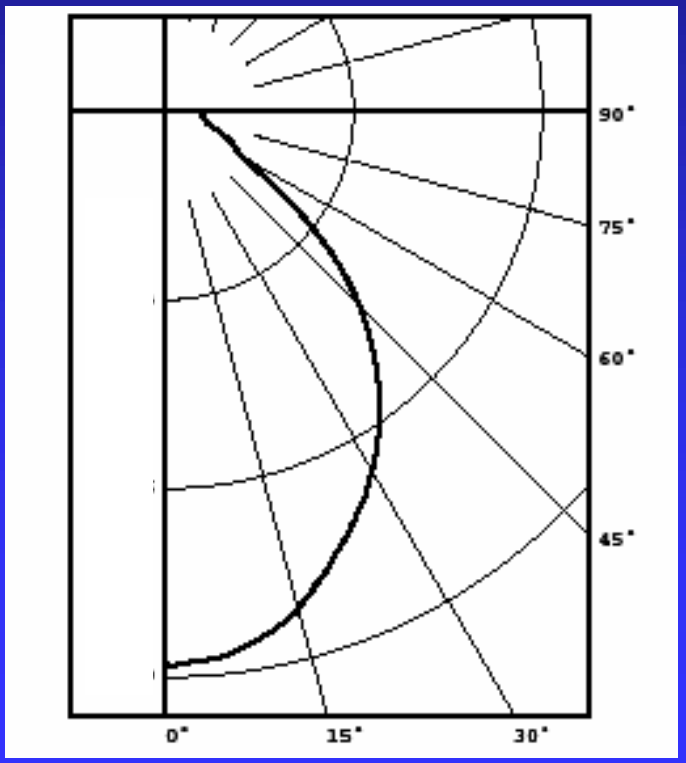
LED Bare Source Photometry

Commercially Available HB
White LED
Polar Candela Plot





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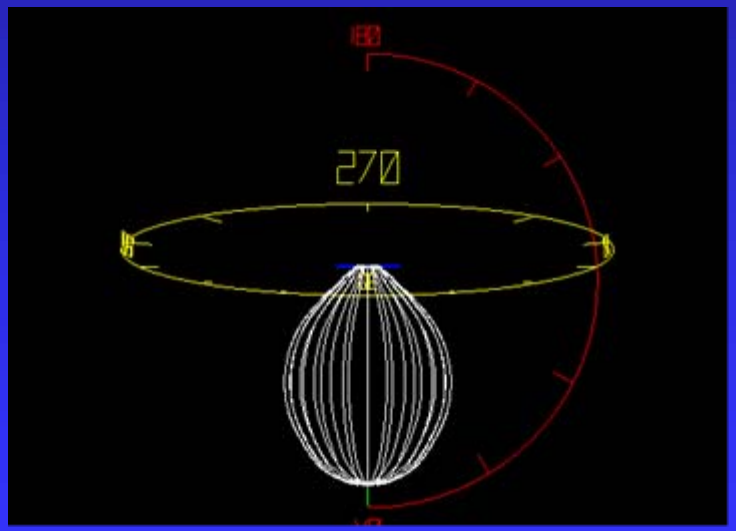
LED Source Emission Offers the Best Opportunity for Optical Control

Optical Control

- Bare LED Package Illustration



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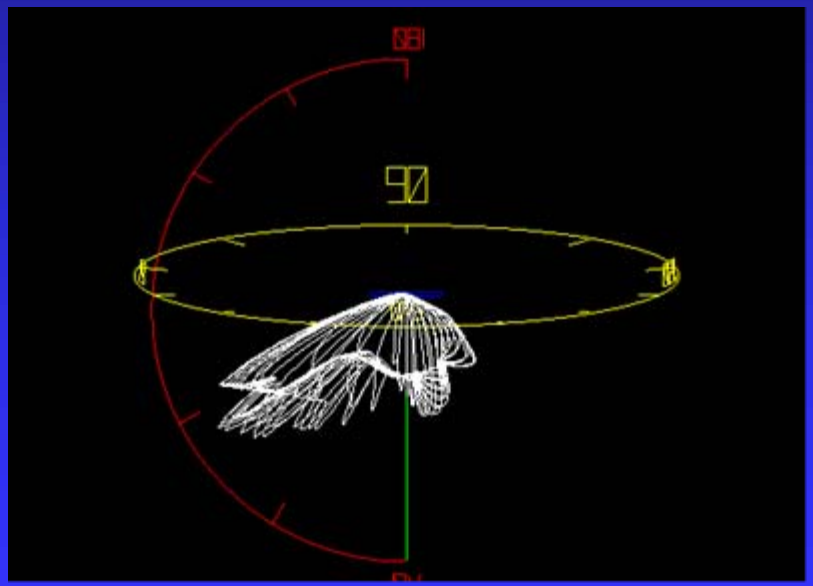
Optical Control

Illustration of Altered Distribution
(Secondary Optic Added)



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What is Needed for a Fair Comparison?

- Certified Photometric Report From an Independent Testing Agency
  - LED System
  - Competing Systems
- Life Data (Lumen Depreciation Value) for the LED System
  - Based On the Life of the Application
    - L70 = end of life limit
- Appropriate Maintenance Factors for the Competing Systems
- Understanding of Costs

❖ Side-by-Side Performance Evaluation

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Other Factors of Comparison

- Complete System Life
- Reliability
- Warranty
- Serviceability and Maintenance
- Chromaticity Selection
- Chromaticity Variation
- Environmental Impact Factors
  - Disposal / Recyclability / etc.
- Etc.

Ongoing LED Improvements

- Increased Efficacy
  - Across all Chromaticity Ranges
- Optical Design
- Thermal Management
  - Materials / Heat-sinking
  - Packaging
- Reduced Chromaticity Variation
- Standards (Updates and Refinements)
  - Test / Measurement / Application
- Driver and Control Technology
- Costs
- Etc.

Opportunities for Application Performance Improvements

- Better Lighting Uniformity
  - Reduction of “Hot Spots”
  - Improvement in Minimum Light Levels

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Parking Area Comparison

LED Area Light

Vs

High Pressure Sodium (HPS) Area Light

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Parking Structure Comparison

LED Parking Structure Fixture

Vs

200W Pulse Start Metal Halide

Parking Structure Fixture

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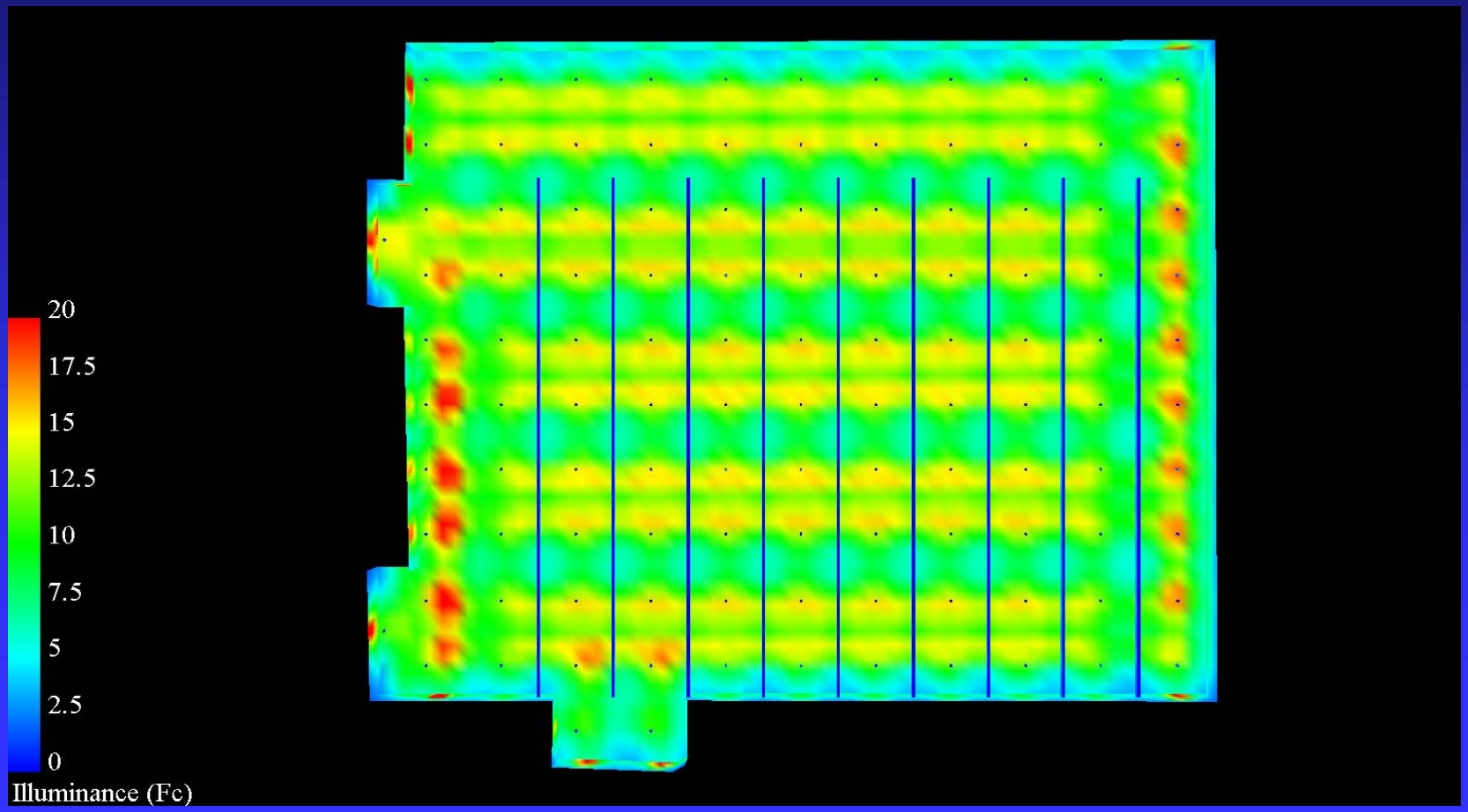
Parking Structure
200W Pulse Start Metal Halide



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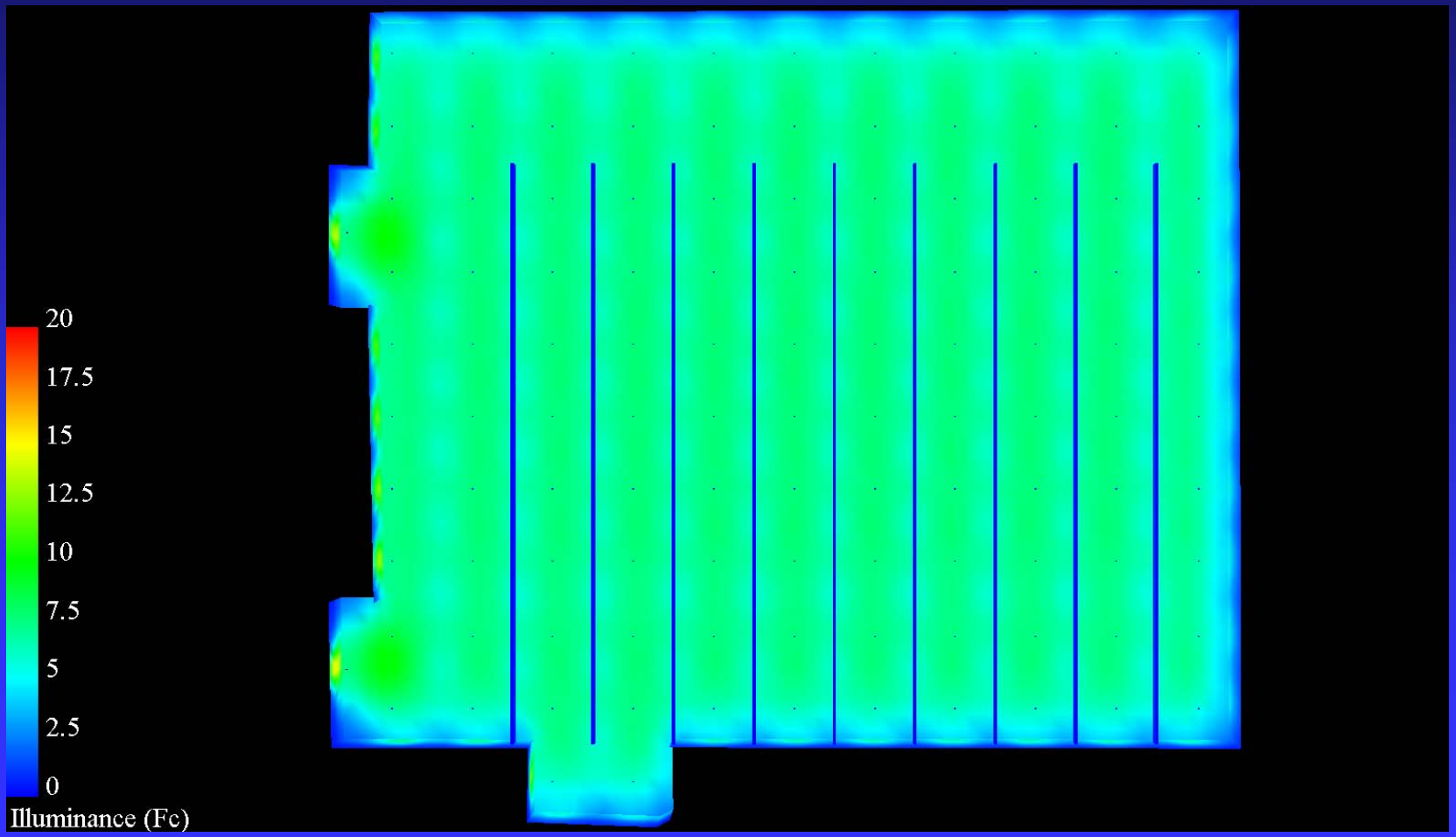
Parking Structure
LED



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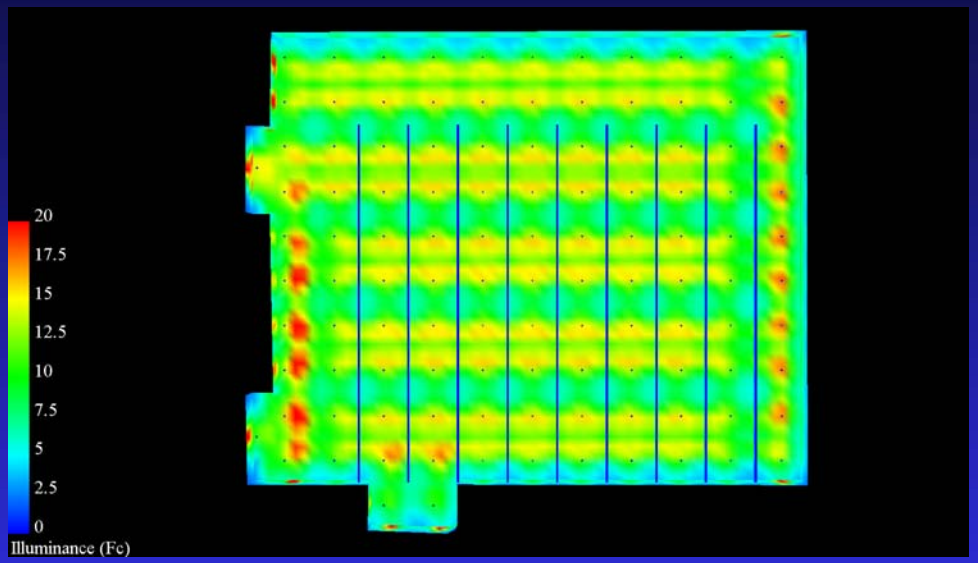
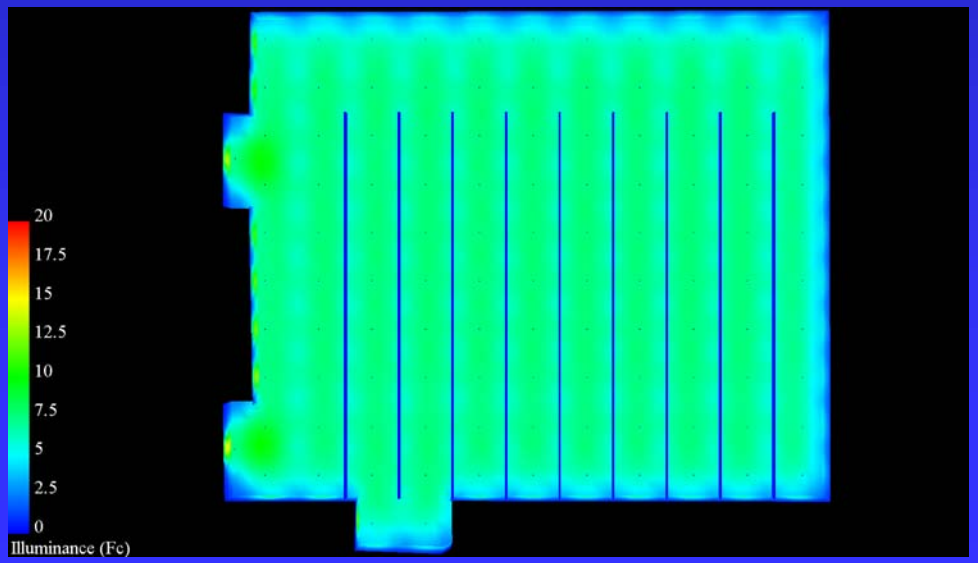
Application Comparison



200W MH Solution

AVG	11.24
MAX	27.7
MIN	2.8
MAX/MIN	9.89:1
LLF	0.8 (@ 6,000 Hrs. Use)
Power	235W



LED Solution

AVG	7.59
MAX	11.6
MIN	2.3
MAX/MIN	5:1
LLF	0.95 (@ 50,000 Hrs.Use)
Power	128W

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Parking Structure
Fluorescent
vs
HB LED

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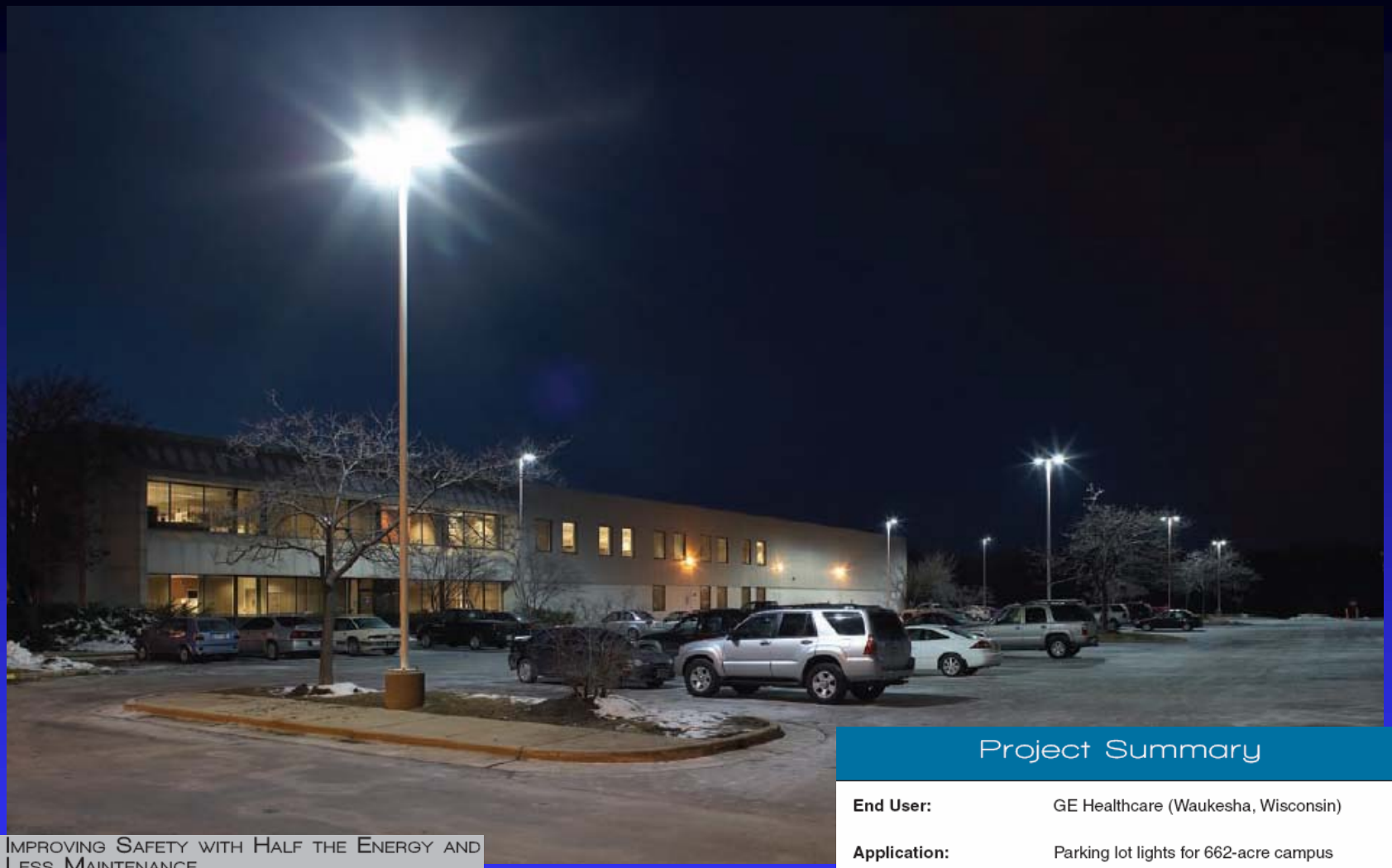

Improving Safety with Half the Energy and Less Maintenance

"With **THE EDGE** from **Beta LED**, we are able to **surpass environmental requirements** and provide better, brighter light to **increase safety**; truly a win-win."

Mark Colannani
Facilities Global Manager
GE Healthcare's

Project Summary

End User:	GE Healthcare (Waukesha, Wisconsin)
Application:	Parking lot lights for 662-acre campus
Product:	272 of THE EDGE™ LED area luminaires
Benefits:	Cut energy in half and decrease energy costs
	Provide better lighting and improved safety for 3000 employees
	Less maintenance – lamps don't have to be changed for over 10 year versus two or three years with traditional high pressure sodium lamps
	Beta LEDs do not contain toxic mercury, commonly found in fluorescent or HID lamps

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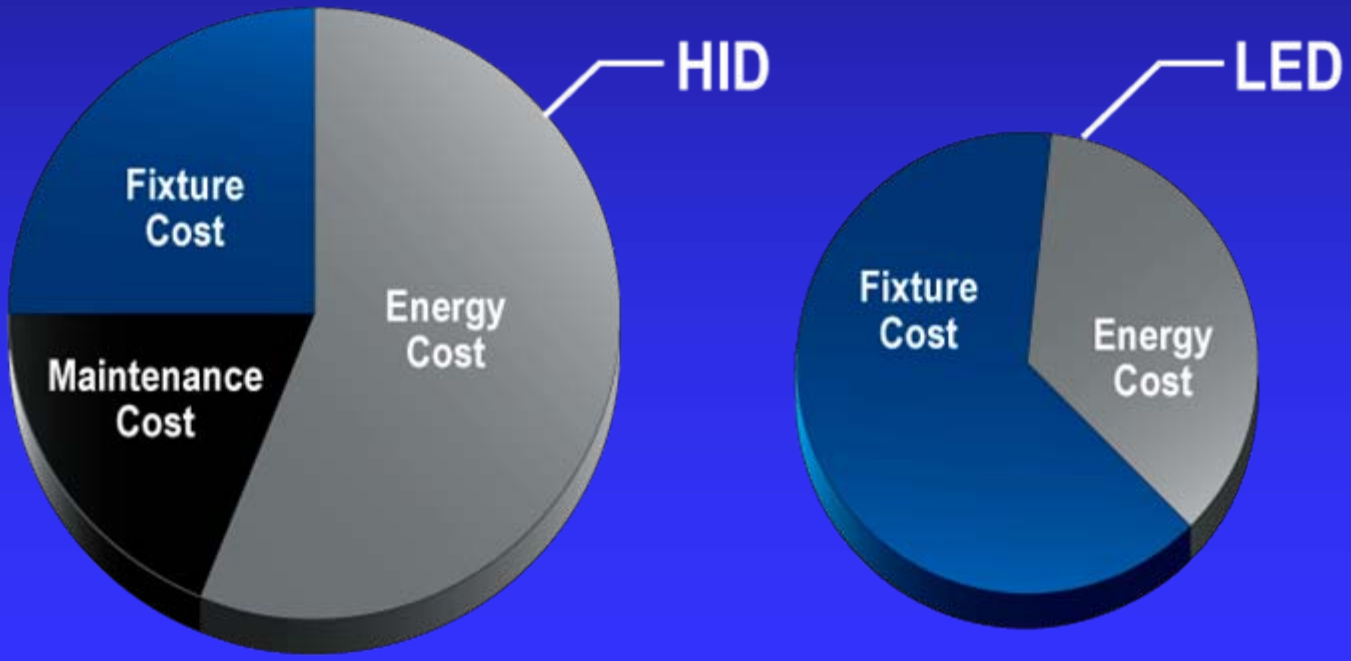
Value Analysis

Total Cost of Ownership Illustration



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Questions?

www.BetaLED.com